(12)

SIXTH QUARTERLY PROGRESS REPORT

FOR

MANUFACTURING METHODS AND TECHNOLOGY (MM&T)

MEASURE FOR FABRICATION OF LOW VOLTAGE

START SEALED BEAM ARC LAMPS

1 Oct. 1977 to 31 Dec. 1977

CONTRACT NO. DAAB07-76-C-0034

U.S. Army Electronics Command
Production Division
Production Integration Branch
Ft. Monmouth, NJ 07703

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A program is in progress to establish a production capability for the purpose of meeting estimated military needs for the X6335, a 1kW sealed beam xenon arc lamp with low voltage starting mechanism.

In accordance with the requirements of the contract, the third engineering sample is still undergoing fabrication to meet specification.

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Improvements were made to reduce manufacturing costs and improve reliability. These included:

a. Molybdenum insert was added to improve heat transfer from anode to heatsink.

b. Anode base changed from steel to copper.

c. Stinger bearings changed to sapphire to reduce friction.

d. New mandrel machined and precision polished.

e. Test bench set-up to evaluate individual reflectors for focal point location and relative output readings.

f. Lamp with demountable electrodes designed to study electrode optimization.

g. Stinger mechanism cycle tested and evaluated.

MANUFACTURING METHODS AND TECHNOLOGY (MM&T) MEASURE FOR FABRICATION OF LOW VOLTAGE START SEALED BEAM ARC LAMPS

SIXTH QUARTERLY PROGRESS REPORT

1 Oct. 1977 to 31 Dec. 1977

"The objective of this manufacturing methods and technology project is to establish the technology and capability to fabricate Low Voltage Start Sealed Beam Arc Lamps".

CONTRACT NO. DAAB07-76-C-0034

By

Roy Roberts
Tim Bell

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ABSTRACT

A program is in progress to establish a production capability for the purpose of meeting estimated military needs for the X6335, a 1kW sealed beam xenon arc lamp with a low voltage starting mechanism.

In accordance with the requirements of the contract, the third engineering sample is still undergoing fabrication to meet specifications.

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1.0 PURPOSE

The objective of this program is to establish a production capability for the purpose of meeting estimated military needs for a period of two (2) years after completion of the contract, and to establish plans which may be used to meet expanded requirements.

The program is intended to demonstrate and to "prove-out" the manufacturing processes, methods and techniques that are utilized in the production of 1kW sealed beam xenon arc lamps with a low voltage starting mechanism.

The lamp initially chosen for the program was the X6257. This lamp was developed for military search-light applications. The high voltage version of this lamp was developed initially under Contract Number DAA02-68-C-0215. The 1kW lamp was further refined on a PEM Contract Number DAAB05-71-C-2609. The low voltage starting X6257 was not developed with government funds, but was developed with Varian funds.

This contract is divided into three phases:

1. Engineering Samples, wherein modifications are being made to designs arrived at under previous development in order to improve their optical performance, safety and utility in the field and to reduce their cost. Production drawings, procedures, and tooling will also be developed. These parameters will be based on delivery of three (3) samples.
2. Confirmatory Samples, wherein the delivery of three

(3) units will be made to demonstrate that lamps can be made with production techniques and procedures to meet the specification.

3. Pilot run, wherein the delivery of thirty (30) units will be made to demonstrate the capability of meeting the planned production rate.

The engineering sample phase is needed to incorporate features which will make the lamp start more reliably, be easier to fabricate, be safer to operate, have a highly accurate mounting surface for optical reference and afford cost reduction.

During this quarter the 3rd Engineering sample underwent improvements to aid heat transfer at the anode base. Reflector location to the cathode tip on various lamp samples was evaluated to optimize candlepower readings.

2.0 GLOSSARY

LVS....................................Low voltage starting.

Stinger................................Moveable electrode used for lamp ignition.

Mandrel................................A stainless steel tool which is polished to a mirrored surface with a special elliptical contour upon which the reflector is electroformed.

EI (characteristic)....................The voltage (E) across the lamp for a given current (I) passing through the lamp.

PBC....................................Peak beam candlepower

EMI....................................Electromagnetic interference

3.0 NARRATIVE AND DATA

The lamp is comprised of conventional tungsten electrodes positioned in a ceramic/metal structure with a reflector and sapphire window. The arc is located at the focal point of the reflector so that a directed beam is obtained coaxial with the electrodes. The low voltage starting mechanism includes a moveable electrode called the "stinger" which is coaxial with the anode.

The lamp is filled with up to 20 atmospheres of high purity xenon at room temperature. The lamp's spectral output is a typical high pressure xenon arc spectrum as reflected from a silver mirror and transmitted through a sapphire window. The wavelength range is about 130nm to 6500nm. The silver reflector coating was selected for maximum output in the visible and near IR bands.

The lamp operating voltage is 19.5 D.C. $\pm$.5v. The lamp voltage is determined primarily by the interelectrode gap and the lamp pressure. The lamp acts much like a constant voltage device, that is, large changes in current result in small changes in operating voltage. Ignition is accomplished by use of the stinger. To commence the start cycle, the solenoid voltage is applied causing the stinger to move forward. The moment the stinger contacts the cathode tip, the electrical circuit is completed and current begins to flow through the choke. After approximately .5 seconds, the solenoid voltage is removed and the stinger starts to return to its deenergized position, thus breaking the circuit.

At this time, the stored energy in the choke is dumped into the arc. The stinger then draws this arc back and transfers the arc to the anode.

To further MM&T progress the following items were investigated during this report period.

a. Anode heat transfer.
b. Anode stress at braze.
c. Stinger bearings.
d. Stinger life.
e. Lamp body integrity.
f. EI characteristics, stability, EMI.
g. Lamp output (PBC)
h. Cathode placement verses arc crossover points.
i. Reflector mandrel contour.
j. De-mountable electrode lamp.
k. Stinger reliability relative to friction in bearings.
l. Stinger vibration test.

3.1 DESIGN AND ANALYSIS

The following paragraphs describe work done during this report period.

1. Signs of melting were noted in the ancde tip after operating the stinger mechanism over 1000 on-off cycles. A molybdenum insert was incorporated to improve heat transfer and thereby reduce anode tip temperature. This insert has been used effectively in the previous low voltage searchlight lamps. The molybdenum insert will also lower the stress at this joint interface.
2. The anode base material was changed from carbon steel to copper in conjunction with the molybdenum insert to improve heat transfer.
3. The anode cooling fins were brazed on the copper heatsink to improve heat transfer from the anode.
4. Stinger bearings were changed from molybdenum and ceramic to sapphire bearings. This improvement offers a lower part cost and lower coefficient of friction against the tungsten stinger shaft. Also stinger parts were silver coated to reduce friction between moving parts and improve electrical conductivity.
5. Functional test of stinger assembly to 6000 cycles, (30 sec. on and 30 sec. off) completed to date.
6. Lamp number 31 of the 3rd engineering sample phase was pressure checked to 1400 psi without rupturing.
7. New elliptical reflector mandrel was machined and controlled polished.

8. Voltage and current (EI) data was established on engineering samples No. 12 and F7V193. The following data (Figure 1) was generated to reflect EI characteristics for the two lamps. The steep shift in the EI occurred beyond 40 amps for engineering sample No. 12 and is attributed to anode braze deterioration which resulted in overheating the anode.
Figure 1 also shows a comparison between an .085 inch gap and a .065 inch gap, for the two engineering samples. The decrease in gap spacing for lamp No.12 had shifted the EI curve closer to MM&T specifications as shown on the attached graph.

9. Peak Beam Candlepower for lamps 11 through 13 were recorded at 20 million candela instead of the 25 million candela specified in the MM&T specifications. The following areas were investigated to remedy the problem.
   a. Cathode placement.
   b. Reflector contour
   c. Surface reflectances.
   d. Cathode size and shape.
   e. Reflector thickness.

10. Flanged elliptical reflectors were optically evaluated for beam crossover points as a possible cause for low peak beam candlepower of 20 M candelas. The theoretical beam crossover point is 2.600 inches from the reflector locating flange. The empircally recorded dimension was 3.6000 inches which severely limited the light beam filling the 5 inch diameter F/1.3 projection optics and thereby reduces PBC output.

11. The reflector mandrel contour was proven inaccurate which accounts for the low PBC output. A new mandrel was machined in efforts to solve the low PBC output problems.

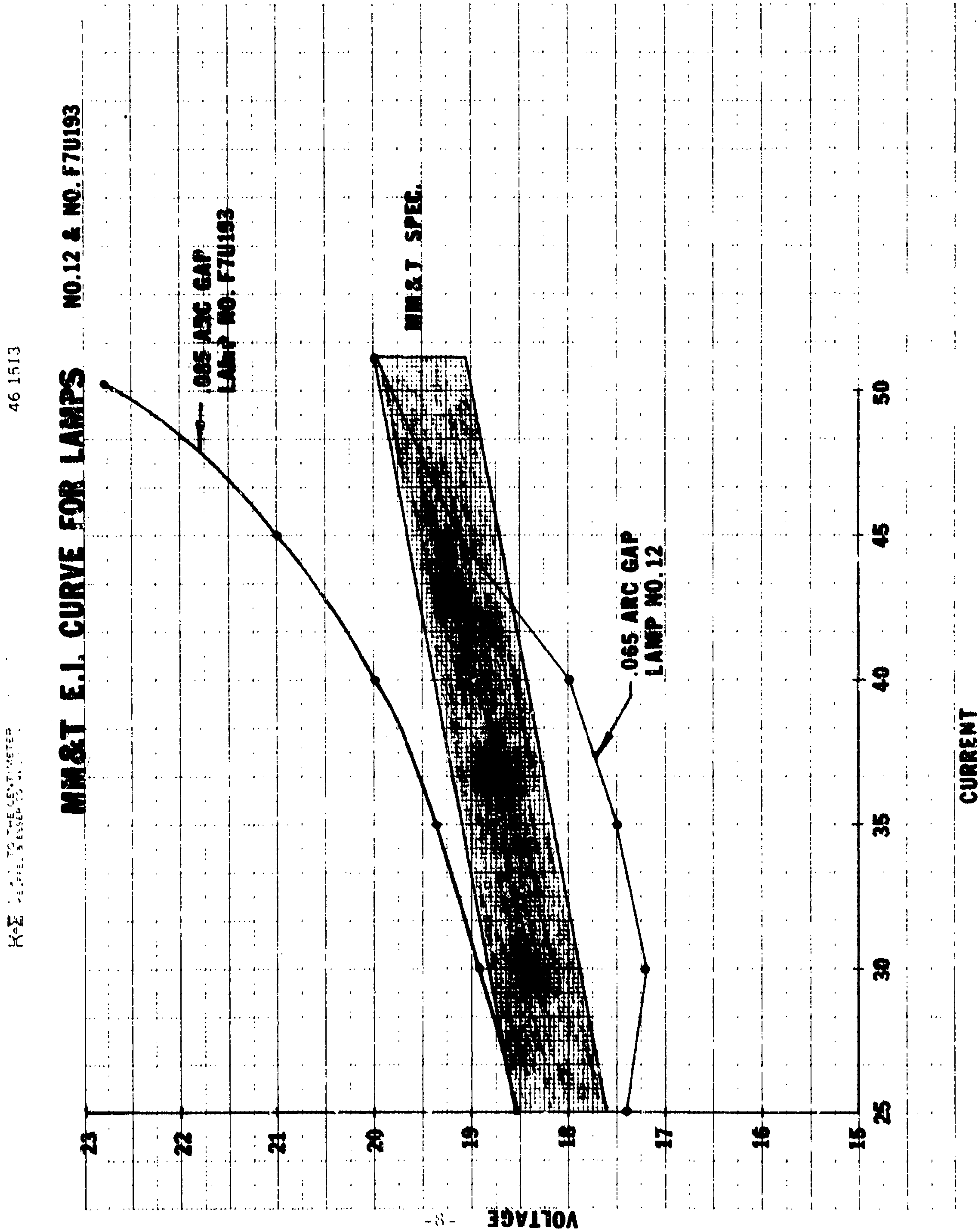
MM&T E.I. CURVE FOR LAMPS
NO.12 & NO. F7U193
.065 ARC GAP
LAMP NO. F7U193
MM&T SPEC.
.065 ARC GAP
LAMP NO.12
VOLTAGE
CURRENT
23
22
21
20
19
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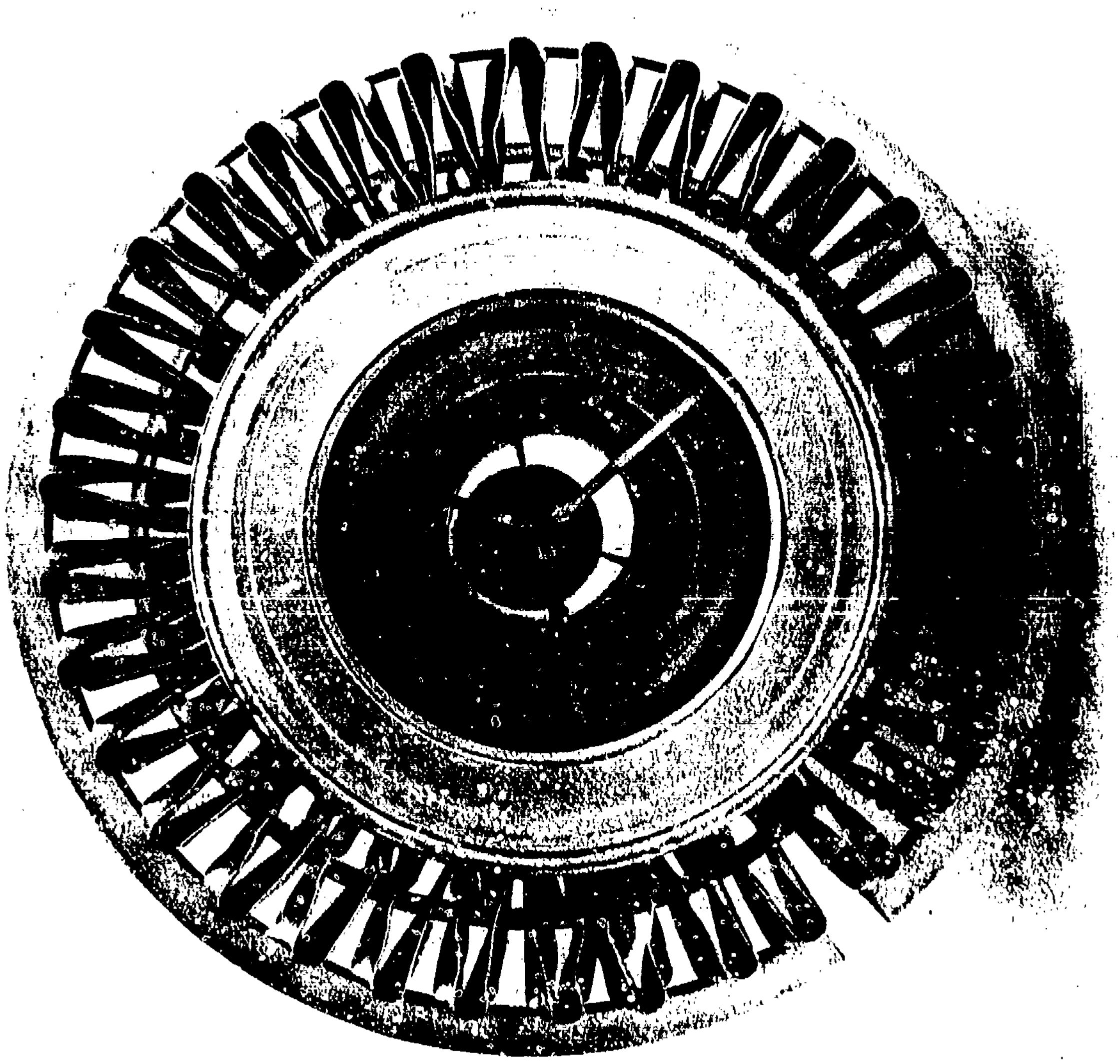
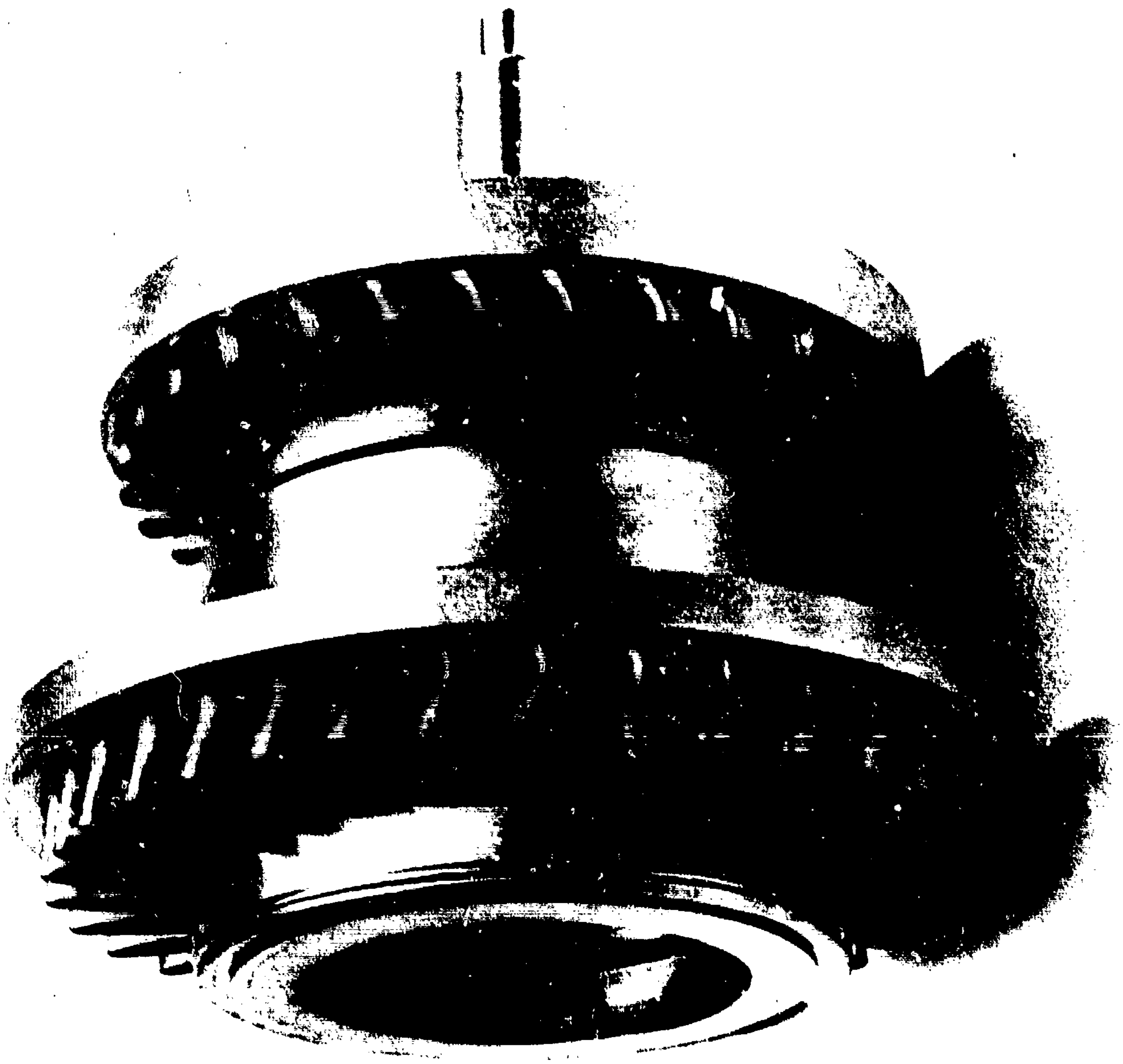
Figure 1



MM&T Lamp Front View

Figure 2



"MM&T Lamp Side View"

Figure 3

MM&T Lamp Rear View

Figure 4

3.2 FABRICATION AND TOOLING

Lamp body parts are being successfully brazed in sub-assemblies with pilot run tooling. Among the progress included is:

1. The molybdenum insert was successfully brazed into the copper heatsink to improve heat transfer from the tungsten anode.
2. New tooling was designed and built to accurately locate the stinger bearing centerlines. This tooling also has provisions to hold concentricity between the main body cup and the anode.
3. Machined parts for the improved stinger mechanism are completed and brazed.
4. The window assemblies were successfully brazed. The window metalizing was revised from copper plating to nickel in order to improve the joint strength.
5. Brazed sub-assemblies were made for the main body and anode cup seal rings.
6. A new flanged reflector mandrel was machined and precision polished to improve PBC output.
7. A lamp with demountable electrodes was designed and is now undergoing brazing operations. This project is totally funded by EIMAC but will be extremely valuable in electrode evaluation of this lamp as well as others.
8. Lamp sub-assemblies and additional tooling for the confirmatory run are being fabricated.
9. Braze washers for the window assembly and main body metal to ceramic seal are completed.
10. Additional sets of tooling are scheduled for manufacture after the initial tooling proves its reliability and effectiveness.

3.3 TESTING

3.3.1 Stinger Mechanism

a. A test was conducted to cycle the stinger mechanism with the lamp operating 50 sec. on and 10 sec. off. The anode showed signs of melting at the tip which ended the test at approximately 1000 cycles.

b. Another test was set up to life cycle the stinger mechanism in a fully functional lamp to determine:

   1. Friction buildup as a function of time as determined by voltage increases in stinger solenoid.
   2. The effect of silver versus copper plated stinger parts. The test was conducted to 6000 cycles of 30 second intervals at 1kw of lamp power without any evidence of stinger mechanism failure.

c. Stinger vibration tests were performed to determine the resonant frequency and stinger rod amplitudes for various stinger armature and spring mechanisms. The vibration loadings were performed coincident to the lamps centerline. At a 20g's vibration loading and a cyclic frequency sweep from 20 to 80 cycles per second no significant stinger movement was noted.

3.3.2 Reflectors

A test has been established to optically verify the accuracy of the elliptical reflectors before installation in a lamp. In addition, this test determines the ideal cathode tip placement relative to the focal point for each reflector. Thus the

reflector focal point location is dimensionally established for each reflector permitting the reflector location and cathode strut position to be optimally established during assembly.

3.3.3 Pressure Test

a. The lamp was subjected to a pressure test to evaluate the lamps pressure capability. The lamp body was subjected to 1400 psi of fill pressure without destruction.

3.4 CONCLUSION

Results of work accomplished during this report period indicate that major progress was made in solving problems associated with the following:

a. Heat transfer from anode.
b. Stinger mechanism reliability
c. Reflector to cathode tip location
d. Lamp body integrity

Completed lamp assemblies are reliably being brazed up to increase the number of sub-assemblies awaiting final lamp assemblies.

4.0 PROGRAM FOR NEXT INTERVAL

1. Finalize all detail drawings and assembly drawings for the MM&T lamp.
2. Investigate with an EIMAC funded de-mountable electrode lamp, the cathode and anode placement as a function of candlepower.
3. Continue to test lamps for reliability.
4. Incorporate improvements as required to optimize peak beam candlepower.

5.0 PUBLICATIONS AND REPORTS

None.

6.0 IDENTIFICATION OF PERSONNEL

The following is a list of key personnel who worked on this contract during the period October 1977 through December 1977.

Roy Roberts	199.0 Hours	
Gordon Liljegren	24.0 Hours	
Nick Picoulin	43.2 Hours	
Welton Jones	345.5 Hours	
Nick Cortese	71.2 Hours	
Alice Estrada	35.6 Hours	
Lavaughn Overton	6.0 Hours	
Vic Kristen	2.0 Hours	
Cheryl Handley	10.0 Hours	(Draftperson)
Greg Guild	211.7 Hours	"
Bob Fehringer	36.0 Hours	"
Glenn Brown	8.0 Hours	"
George Calkins	9.0 Hours	"
Paul Wierenga	16.0 Hours	"

The resume for Mr. Martin Wolfe and Ms. Alice Estrada are included in this report. Mr. Wolfe is a master technician with EIMAC and will be allocating appropriate time to the MM&T project. Ms. Estrada is a tube technician allocating appropriate time to the fabricating of braze assemblies of the MM&T project.

MARTIN E. WOLFE

Mr. Wolfe has been employed by EIMAC for thirty four years and is familiar with all areas of technology relating to lamp development. Mr. Wolfe's current responsibilities include brazing assemblies and design of brazing fixtures, and in the manufacture of xenon lamps.

Mr. Wolfe's recent experience includes new product development in the areas of cathodes, lasers, and traveling wave tubes. In addition, he assisted in developing ceramic metalizing techniques and the design and fabrication of ceramic to metal seals. This experience will be invaluable to further efforts on the MM&T lamp program.

Mr. Wolfe has also worked at a supervisory capacity in developing manufacturing methods and techniques for production workers in the vacuum industry.

ALICE R. ESTRADA

Ms. Estrada joined EIMAC in 1946 as a recent graduate of the College of San Mateo. Ms. Estrada started working in the testing department of the Vacuum Tube Division and moved progressively through the departments of the division and achieved supervisory status. This experience provided a professional background in the operation of the various types of machinery and techniques employed in the tube division.

Ms. Estrada then was assigned to the Advanced Products Model Shop as a technician, which furthered her knowledge in the areas of research and development. The techniques employed were quartz to metal seals, thin film deposition, vacuum system brazing and ionic evaporation sputtering. The major commodity areas were xenon arc lamps in pre-production development, Apollo Space Lights, Tow Lamp program, and presently on the one kilowatt low-voltage lamp. Ms. Estrada is presently making final assemblies for the xenon arc lamps initial stage to completion.

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